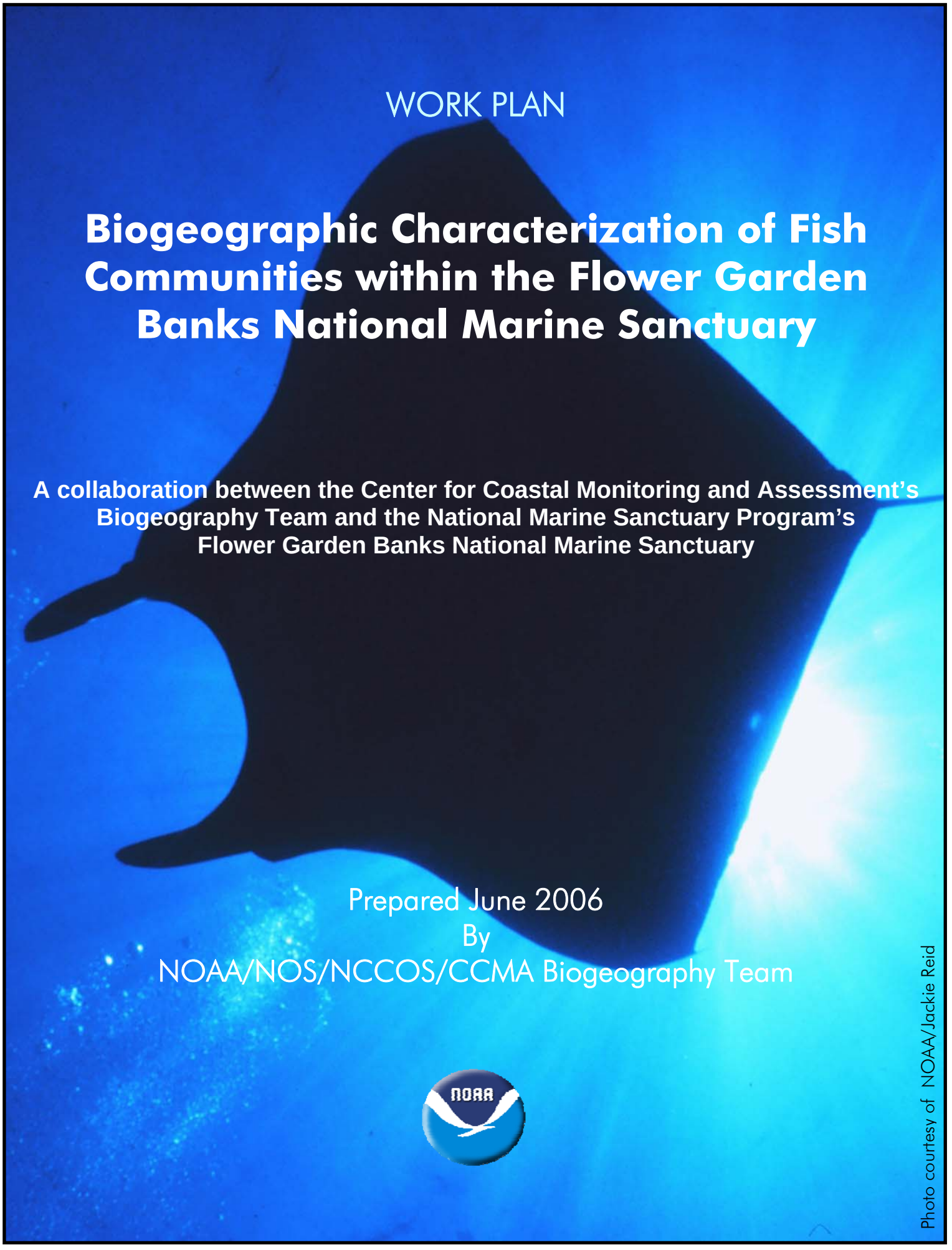
WORK PLAN

Biogeographic Characterization of Fish Communities within the Flower Garden Banks National Marine Sanctuary

A collaboration between the Center for Coastal Monitoring and Assessment's Biogeography Team and the National Marine Sanctuary Program's Flower Garden Banks National Marine Sanctuary



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By

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Photo courtesy of NOAA/Jackie Reid

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Goal

The overarching goal of this collaboration is to provide the Flower Garden Banks National Marine Sanctuary (FGBNMS) staff with information on the biogeographic patterns within the Sanctuary critical to decision making. This specific project will focus on the development of a plan to spatially and quantitatively characterize the benthic fish community throughout the Sanctuary. This collaboration will also include the initial implementation of that plan in the diveable portion of the coral cap environment.

Objectives

1) To design a spatially robust sampling strategy to quantify in a spatially robust manner the status of the benthic fish community associated with the diveable portion of the coral cap regions within the Sanctuary;
2) To carry out the initial implementation of this sampling strategy;
3) To design a spatially robust sampling strategy to quantify in a spatially robust manner the status of the benthic fish community associated with the portion of the Sanctuary not reachable by standard SCUBA diving techniques; and
4) To develop a GIS based tool that will assist with the implementation of both strategies including site selection.

Background

The Flower Garden Banks National Marine Sanctuary (FGBNMS) represents the northernmost tropical western Atlantic coral reef on the continental shelf and supports the most highly developed offshore hard bank community in the region. The complexity of habitats supports a diverse assemblage of organisms including approximately 250 species of fish, 23 species of coral, and 80 species of algae in addition to large sponge communities. The Sanctuary was designated in 1992 and currently serves to protect the local resources via regulations such as the prohibition of discharging pollutants, exploration for oil and gas, sea bed alterations, anchoring, or removing living or non-living Sanctuary resources. Fishing, both commercial and recreational, however, is permitted within Sanctuary waters.

Monitoring of these communities has taken place at FGBNMS since the 1970s. This work has focused primarily on monitoring the benthos with video transects and photostations documenting transitions between coral, algae and sponge communities over time. Until relatively recently, little has been done to monitor or characterize the reef fish community *(*but see Boland et al. 1983, Dennis 1985,Gittings et al. 1993, Dokken et al. 1999, Pattengill-Semmens et al. 2000). In 1994 the Reef Environmental Education Foundation (REEF) began surveys of the Sanctuary and utilized a combination of REEF personnel, volunteers, and Sanctuary staff to visually census reef fish populations via roving diver surveys. These surveys have been invaluable in terms of species list development and understanding the ranges of these species. Subsequently, a more

quantitative approach was taken by Pattengill (1998) who utilized a stationary point-count technique to begin to quantify community metrics such as species abundance and trophic structure at selected locations. This technique has also been employed since 2002 by PBS & J in their current monitoring efforts at the FGBNMS. These two data sets provide an important starting point for characterizing the fish community. However, these historical data are limited in scope of inference to small portions of the Sanctuary coral cap environment and are therefore difficult to utilize in developing population estimates at the scale of the Sanctuary.

In addition to the relatively small area covered by prior studies, adequate spatial characterization of the FGBNMS has been hindered by the lack of a spatial framework necessary for developing an effective sampling design. Recently, the FGBNMS has completed development of a fine-scale habitat map suitable for stratifying studies of reef fish communities by habitat type. This spatially resolved assessment of the bottom types in the Sanctuary will provide the framework necessary to more efficiently characterize and quantify benthic fish communities within the Sanctuary. This effort will complement the inventory work conducted to-date and is critical to both sanctuary inventory and management activities.

Statement of Work

To develop a spatial and quantitative description of the fish resources inside the Sanctuary, multiple survey techniques will need to be employed. For sampling purposes, the Sanctuary will be divided into two regions. The first is the diveable portion of the coral cap communities. The second is the region too deep to dive where other techniques such as ROVs and drop cameras will need to be employed. The diveable region (< 33m) of FGBNMS is approximately 1% of the total area of the Sanctuary. This area is generally coincident with the complex habitat that forms the coral caps on the East and West Banks. The remainder of the Sanctuary consists of coral cap regions too deep to dive, followed by a low diversity reef zone, algal-sponge zone, nepheloid layer, and brine seeps (DOC 1991).

Initial sample allocation and survey design for the diveable portion of the coral cap community will be informed by comparable data and methodologies employed in the US Caribbean. These aspects will then be modified as data is collected throughout the course of this project. Once designed, the sampling protocol will be implemented over two missions to provide spatial characterization and baseline data for monitoring. The development of a characterization plan for the deeper water environments will follow a similar course of action, but will not have the advantage of existing survey data. Both designs will be greatly aided by the development of a GIS tool to assist with the implementation of the sampling design, including site selection.

Project Tasks

Task 1: *Initial project planning*

Initial conference calls and meetings will be held to scope out the specific project goals and objectives. Decisions will be made to define the study domain and determine the relevant taxa on which to focus. Also, initial discussions will be held to identify

biological and physical data sets relevant to the biogeographic characterization. These discussions will be integrated into the evolving project work plan. A webpage will be created to aid in communication of this effort to partner agencies and the public. The work plan will be updated as the project evolves and will be available in PDF format on the webpage for interested parties.

Products:

- Draft work plan (June 2006)
- Web page (June 2006 – with ongoing updates)
- Final work plan (August 2006)

Task 2: *Data collection*

Meetings held to-date have resulted in the definition of the survey domain. The domain consists of the area contained within the East and West Flower Garden Banks National Marine Sanctuary boundaries. The domain is further divided into two separate components (diveable and too deep to dive) based on their ability to be surveyed directly by divers or indirectly through remote sensing techniques. It was also agreed that initial surveys will include the entire benthic reef fish community. If it is determined that all species are not able to be identified and enumerated during a survey, a more focused species list will be developed. Based on these constraints biotic data sets will be identified that are relevant to both the domain and the species of interest and their utility evaluated. In order for these data sets to be of use they must also survey a constant area and basic estimates of variance must be calculable from the data for all strata identified.

Products:

- List of researchers with potentially relevant data on fish communities at the FGBNMS (June 2006)
- Final evaluation of data utility (August 2006)

Task 3: *Sample design for diveable portion of the FGBNMS*

Throughout the planning process (*Task 1*) the Biogeography Team advised FGBNMS staff that a stratified random sampling design may be better than a simple random sampling design, because of potential improvements to the precision of common community and species specific metrics (e.g. fish density, fish species diversity, coral cover). Typically a domain analysis of community and population metrics calculated from previously collected data is used to resolve strata, but the spatial extent of previously collected data was inadequate for analysis. Instead, fine-scale bathymetry maps and FGBNMS staff diver experience were used to resolve a suitable stratification variable. Slope (i.e. gradient) was chosen because it is considered a covariate of distinct fish communities and thus would likely increase metric precision. A visual examination of slope derived from the fine-scale bathymetry maps showed that slopes between 0° – 35° and 35° – 90° were suitable groupings for strata designations. Other slope groupings were examined, but were rejected based on inadequate spatial differentiation or cumulative area.

The FGBNMS sampling design will be adaptive to increase metric precision as new information is acquired and management needs evolve. The September 2006 field

mission (Task 4) will use strata based on the slope groupings defined above. Seven representative community and taxa-specific metrics will be investigated: community species richness, community abundance, community biomass, snapper abundance, snapper size, grouper abundance and grouper size. Metrics may change in subsequent field missions to adapt with changing FGBNMS management requirements.

Sampling design efficiency (i.e. relative to a simple random sampling design) will be evaluated using metric estimates according to Cochran (1977). In addition, domain analyses will be used to identify if alternative stratification schemes (e.g. depth, coral community) are advantageous.

Sample size will be determined based on the product of the number of diving days, number of diving teams, and the number of dives per team. Initially, sample size will be allocated among strata according to stratum area. After the September 2006 field mission and stratum specific variance estimates can be determined, an Optimal Neyman allocation scheme will be employed to allocate samples. A GIS tool described in Task 6 will make optimization of sampling effort and sample site selection a relatively simple process in the future.

Products:

- Report (Draft: January 2007) detailing the sampling design selection process including:
  - stratification and allocation scheme used for September 06 FGBNMS survey;
  - sampling design efficiency statistics and domain analyses of alternative stratification schemes (e.g. depth, coral community)
  - suggested sampling design for future surveys using results from sampling design efficiency and domain analyses;
  - estimates of sample size necessary to obtain predefined levels of precision for selected community and taxa specific metrics;
  - detailed methodology necessary to effectively implement the suggested sampling design; and
  - example data sheets
- Final Report (w/o revised sampling statistics from early 07 survey; March 2007)
- Final Report (May 2007)

Task 4: *Implementation of sample design for diveable portion of the FGBNMS*

Fish censuses will be conducted according to the Biogeography Team's protocols developed for monitoring fish communities in hard and soft bottom habitats (http://ccma.nos.noaa.gov/ecosystems/coralreef/reef_fish/protocols.html). This method utilizes a transect survey technique that is well suited to the complex habitats of FGBNMS allowing the diver to see under as well as on the distal side of structures. The approach requires only 15 minutes to complete a 4*25 m ($100m^2$) transect at a single site (actual dive time is somewhat longer). Standard and safe diving practices dictate that a second diver be in the water at the same time as the fish survey diver. This diver will be responsible for collecting relevant benthic habitat data to be determined jointly by FGBNMS and Biogeography Team staff as well as possibly information on marine

debris. Two field missions will be planned one in Sept 2006 utilizing the R/V Nancy Foster and the other early in 2007. Additionally, the feasibility of sending a two person team out to FGBNMS prior to Sept. will be explored. The purpose of this effort would be to refine survey methodologies based on bottom time (e.g. Can all species be enumerated effectively? What level of detail can be included in the assessment of benthic habitat given time constraints?). An offline database entry program will be created for ease of use while in the field. Additionally, an online query module will be developed so the database will be readily accessible to different user groups.

Products:

- Final agreement on field data collected (August 2006)
- Offline database developed (September 2006)
- Raw data (after each mission)
- Data summaries/Trip reports (after each mission)
- Online database developed (November 2006)
- Metadata (May 2007)

Task 5: *Sample design for areas of FGBNMS too deep to dive*

The survey of the deeper water environments that compose the majority of the Sanctuary will necessarily utilize techniques other than SCUBA. The preferred technique, regardless of methodology will utilize a random sampling design to obtain a comprehensive assessment of the deep water environment. Areas too deep to dive will be divided into at least two strata: the coral cap community and hard-bottom regions within the remainder of the Sanctuary. Note: Soft bottom habitats outside of the coral cap community will not be assessed.

FGBNMS staff will evaluate in-house ROV fish data to determine if it currently exists in a readily useable format (i.e. has been QA/QCed, exists on one spreadsheet/ database). FGBNMS staff will provide examples of the data and a simplified metadata – to include: brief description of survey methodology, site selection process, number of surveys conducted/mission, number of missions, dates, spatial coverage, species identification process, and species identified. This data set will be evaluated in terms of whether it can be utilized for optimizing a purely random stratified sample allocation based on variance estimates. See Task 6 for a description of a GIS based tool that will make optimization of sampling effort and sample site selection a relatively simple process. The dataset will also be evaluated to determine if it can be included as an appendix to the report developed in Task 7.

Products:

- FGBNMS in-house data and simplified metadata (October 2006)
- Report detailing the sampling design selected (Draft January 2007)
- Final Report (March 2007)

Task 6: *Tool development to aid survey design, planning, and analysis*

In order to design and carryout surveys in an effective and efficient fashion, a tool will be developed that will integrate survey design planning and analysis equations into a

GIS environment. This tool will provide a user friendly interface for Sanctuary researchers to plan field missions.

Products:

- The survey planning tool will:
  - calculate survey estimates (e.g. species richness, species diversity, grouper abundance) from point data for the whole community and for individual habitat types;
  - allow users to view survey estimates in a GIS environment and export results to statistical software;
  - determine sample size for stratified random sampling designs based on pilot, previous, or user inputted survey estimates;
  - randomly allocate sample points according to proportional or optimal allocation schemes and export results to summary tables for analysis in statistical software;
  - provide map of points for use in the field; and
  - provide GPS coordinates for allocated sample points for use in the field (February 2007).
- Basic training on how to use the tool (March 2007)

Task 7: *Characterization of fish assemblages for diveable portion of the FGBNMS*

To provide an adequate characterization of the reef fish assemblages a variety of analyses will need to be performed at the community level as well as for selected species. General summary statistics will be developed to provide descriptive data for examining general patterns of fish distribution. More rigorous analysis will be conducted to examine the relationships between fish (species-specific and community) and the GIS layers available (bathymetry, habitat type) and between the fish and *in-situ* habitat data collected. Fish communities will be examined and compared using common community metrics (species richness and diversity) to identify diverse regions within FGNMS. Density and total estimates of specific target assemblages within the diveable portion of the FGBNMS will be provided.

Products:

- Develop analytical methods (October-November 2006)
- Generate report outline (November 2006)
- Data analysis (October-May 2007)
- Report characterizing the fish community within the diveable portion of the FGBNMS (Draft June 2007)
- Final Report (August 2007)

Project Team

This effort is a collaboration between the National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment's Biogeography Team and the National Marine Sanctuary Program's Flower Garden Banks National Marine Sanctuary. Various

staff within both programs will be involved at different stages throughout this process. Below is an abbreviated list of project personnel and their primary roles in this effort.

Chris Caldow (Project Manager)
Oversee all project tasks; project planning; mission planning; data collection; analyses; report writing

Charles Menza
Analytical lead (Tasks 3 & 5); data collection; analyses; report writing

Randy Clark
Analytical lead (Task 7); data collection; analyses; report writing

Kimberly Woody
Implementation lead (Task 4); data collection; mission planning; report writing

Eric Finnen
Development lead (Task 6); training

Emma Hickerson (Co-PI)
Data collection; review reports; mission planning; provide FGBNMS ROV data

GP Schmahl
Review reports; data collection

Doug Weaver
Mission planning; provide data; data collection; GIS tool training

Mark Monaco (BT Lead)
Review all documents; aid in planning

Tim Battista
Remote sensing specialist